Feasibility Study on Freezing and Handling Fresh Hams in Corrugated Fiberboard Pallet Bins

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FEASIBILITY STUDY ON FREEZING AND HANDLING
FRESH HAMS IN CORRUGATED FIBERBOARD PALLET BINS

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SUMMARY

The feasibility of freezing fresh hams in bulk lots in fiberboard pallet bins for subsequent frozen storage and shipment to processors was tested. Bin loads of fresh hams were treated with CO_2 snow or equipped with an air column in the center to assist heat removal.

The freezing rates of the bin loads of hams were tested in two types of freezer rooms: (1) A conventional blast freezer room and (2) a forced-air freezer storage room. The bin loads of hams in the blast freezer froze at a rate fast enough to provide a low spoilage risk. Whereas, in the forced-air freezer room, where the air temperatures were higher and air velocities lower, the freezing rate of the hams in the pallet bins was not fast enough to prevent the risk of spoilage.

It would take approximately 8 days to freeze a pallet bin of hams to an average temperature of 0° F in a blast freezer using either CO_2 snow or an air column to assist refrigeration. Freezing fresh hams in pallet bin lots does not appear commercially feasible in terms of energy and reduced utilization of blast freezer equipment.

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1/ Respectively, agricultural marketing specialist, agricultural economist, Transportation and Packaging Research Laboratory, Agricultural Marketing Research Institute, Agricultural Research Service. Mr. James is presently employed by the Agricultural Stabilization and Conservation Service, USDA.

The freezing study was conducted at the Cloverleaf Cold Storage Co., in Sioux City, Iowa. Appreciation is expressed to David Feiges, President, and Harold Jensen, Storage Superintendent for use of company facilities and their assistance in making the research possible.

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INTRODUCTION

The handling and shipping of fresh hams from packing plant to refrigerated warehouses for intermediary frozen storage and on to processors in corrugated fiberboard pallet bins has developed into a major industry practice during the 1970's. Up to 2,000 pounds of fresh hams are handled in each bin and the meat must be removed piece by piece from each bin and hand-stacked on wood pallets for freezing. The bins are destroyed in the process of unloading the hams. After freezing and storage the hams are removed from the pallets and are loaded in new fiberboard bins for shipment to a processing plant for curing. Potential exists for economic savings in labor and packaging materials and improved sanitary handling if the hams can be frozen and subsequently distributed through the entire warehousing cycle without removing them from the original bin in which they were packed and shipped. However, many problems associated with commercial bulk freezing of hams may offset what appear to be potential benefits.

The literature of past research is quite comprehensive concerning heat transfer characteristics of pork carcasses, individual hams, and ground pork during freezing. It is difficult, however, to use this information in predicting the freezing rates of fresh hams packed in pallet size fiberboard bins under commercial operating conditions. Here, there are a number of additional variables affecting heat removal for which there is little or no background research. More important of these variables are the thermal resistances of the corrugated bin, the polyethylene bin liner, and air trapped in cavities between the meat cuts. The use of a polyethylene wrapper, for example, was found to more than double the freezing time required for cubes of ground pork compared to unwrapped cubes. 2/

Another very important factor affecting the freezing rate of bulk lots of meat is the mass thickness. Increasing the thickness of packaged fish fillets from 1 to 2 inches increased the freezing time on a plate freezer from 60 to 180 minutes. 3/ The implications here are quite apparent for pallet bins of hams where mass thickness may be up to 45 inches.

2/ Dunker, C. F., and Hankins, O. G. Rates of Freezing and Thawing Meats. Food Technology, pp. 505-508, 1953.

3/ Slavin, J. W. Freezing Seafood--Now and in the Future. Amer. Soc. of Heating, Ref. & Air Cond. Eng. Journal No. 5, pp. 43-48, 1964

To determine the feasibility of freezing fresh hams in bulk lots in pallet bins the following questions need answering: (1) Can heat be removed from the bin loads at a sufficient rate to prevent spoilage? (2) If so, will the cost of refrigeration be prohibitive? (3) Will the processor be able to separate the individual pieces of meat for thawing without the use of excess labor or specialized equipment? This study attempts to answer these questions.

PROCEDURE

At a Midwestern meat packing plant and a public refrigerated warehouse, feasibility studies of freezing fresh hams in fiberboard pallet bins were conducted. Preliminary freezing tests in a commercial blast freezer had shown that full pallet bins of meat would not freeze fast enough to prevent spoilage without either modifying the bin to assist heat removal or using a supplementary refrigerant within the pallet bin. For this test, three methods of supplementing or assisting blast freezer refrigeration were used: (1) Distributing carbon dioxide (CO_2) snow over each layer of hams in a bin; (2) inserting a perforated fiberboard air column vertically in the center of a bin load; and (3) using both CO_2 snow and an air column in a bin load. (Figs. 1 and 2.)

Figure 1.--A perforated fiberboard air column inserted vertically in a pallet bin of hams to assist freezing.

Figure 2.--CO_2 snow placed in a pallet bin of hams to assist freezing.

The test bins had outside dimensions of 45 x 38 x 36 inches and were lined with a polyethylene bag. Approximately 1,700 pounds of hams grading in the 14- to 17-pound weight range were loaded in each bin. A sheet of polyethylene was spread over each layer of hams to prevent the entire bin load from freezing together in a single mass and to facilitate unloading the frozen hams from the bins. One hundred pounds of CO_2 snow was applied in bin loads receiving this treatment. In bins using air columns, the columns were 4 x 4 x 36 inches with six perforations 1½ inches in diameter on each of the four sides. The air columns were constructed so that both top and bottom ends were open to act as flues for air circulation.

As the hams were packed in each bin, thermocouples were inserted in the center of five hams in each bin to measure temperatures. The hams with thermocouples were placed in equally spaced positions running diagonally from top to bottom corners across each bin. Temperature of the hams at the time they were packed in the bins ranged from 32° to 42° F.

After the hams were packed in the bins they were trucked to a nearby refrigerated warehouse. The six bin loads of hams were divided into two sets. Each bin in each set received one of the three indicated treatments to supplement refrigeration. One set of three bin loads of hams was frozen for 5 days in a conventional blast freezer room with horizontal air blast over the bins. The other set was frozen for 5 days in a forced-air freezer room with air blowing vertically from ceiling to floor.

Temperatures in the blast freezer room with horizontal air movement ranged from -12° to -23° F and air speed over the top of the bins ranged from 500 to 700 feet per minute (fpm), 200 to 300 fpm under the bins, and 100 to 125 fpm through the center columns. Temperature in the forced-air freezer room with vertical air movement ranged from -2° to -12° F, and air speed around the bins ranged from 125 to 200 fpm and 60 to 90 fpm through the center columns.

RESULTS AND DISCUSSION

The time temperature relationship of hams during freezing in the three test bin loads in each of the two types of freezer rooms and for the three methods of supplementary refrigeration are shown in figures 3 and 4.

Three curves are plotted for each bin showing (a) maximum--the center temperature of the sample ham with the highest temperature reading; (b) average--the average center temperature of the five sample hams in the bin; and (c) minimum--the center temperature of the sample ham with the lowest temperature reading.

Effect of Refrigeration Assists

Of the three methods used to supplement or assist the freezers in removing heat from the bin loads of hams, no method showed a marked advantage over the other. In bins where CO_2 snow was added the center temperature of hams reached the 30° to 35° F range approximately 6 hours faster than the center temperatures of hams in the bins where just an air column was used. While the initial temperature reduction was slower in bins using just an air column, at the end of the 5-day freezing, the temperature of the meat in bins with just an air column was nearly the same as that in bins treated with CO_2 snow or a combination of CO_2 and an air column. In heat removal combining both the CO_2 snow and air column provided little or no advantage as compared with using either CO_2 snow or an air column alone in the bins. (Figs. 3 and 4).

Effect of Type of Blast Freezer

As expected, the meat in the conventional blast f
temperatures ranged from -12° to -23° F and air velo
faster than meat in the forced-air freezer storage
ranged from -2° to -12° F and air velocities were
that the average center temperature of hams in the
freezing (28° F) about 12 hours sooner than those
room.

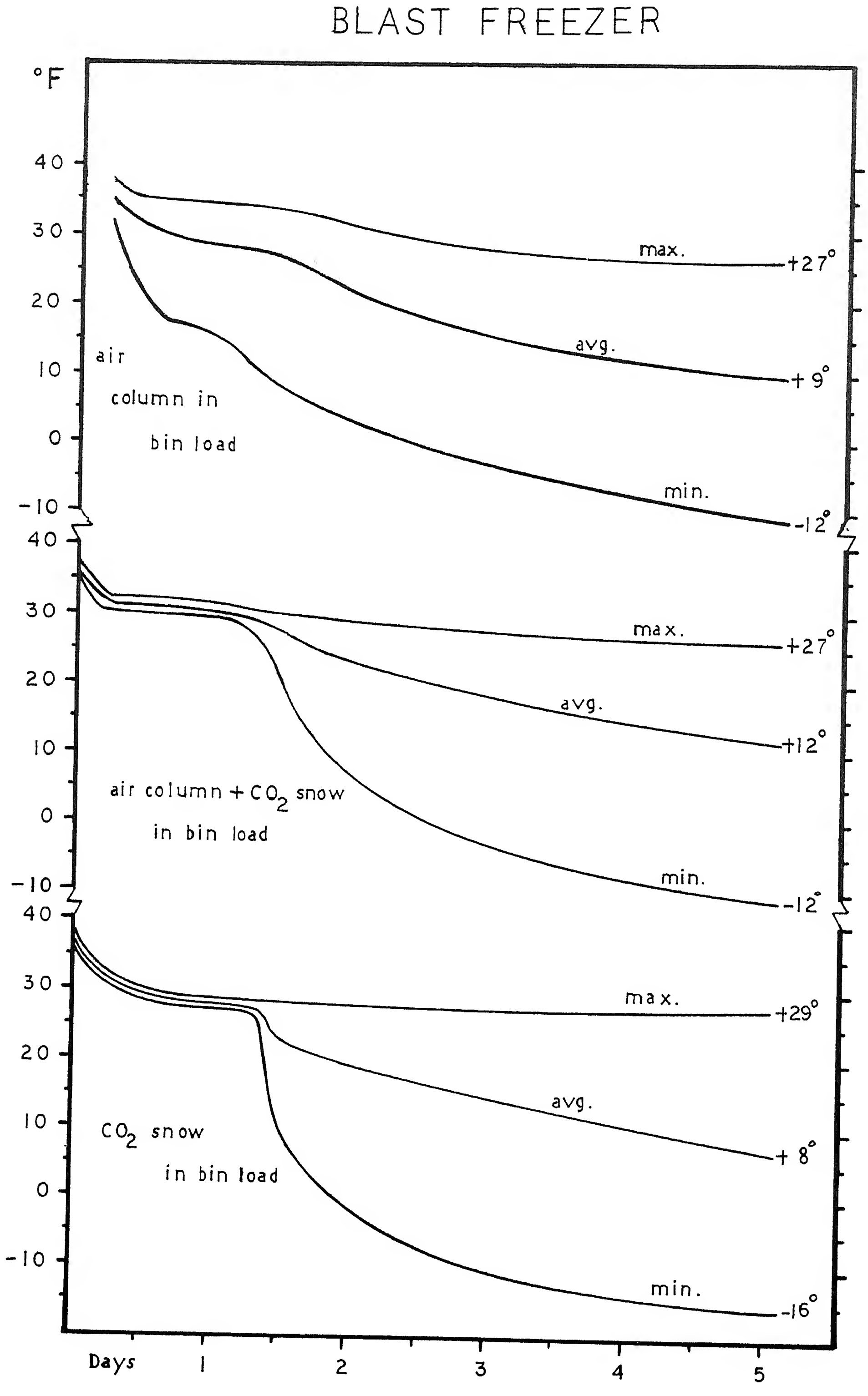

Figure 3.--Freezing curves for three pallet bins of hams in a blast freezer room at -12° to -23° F and air velocities around the bins ranging from 500 to 700 fpm. The average curve is the mean temperature of five hams, whereas the maximum and minimum curves represent the temperature of a single ham.

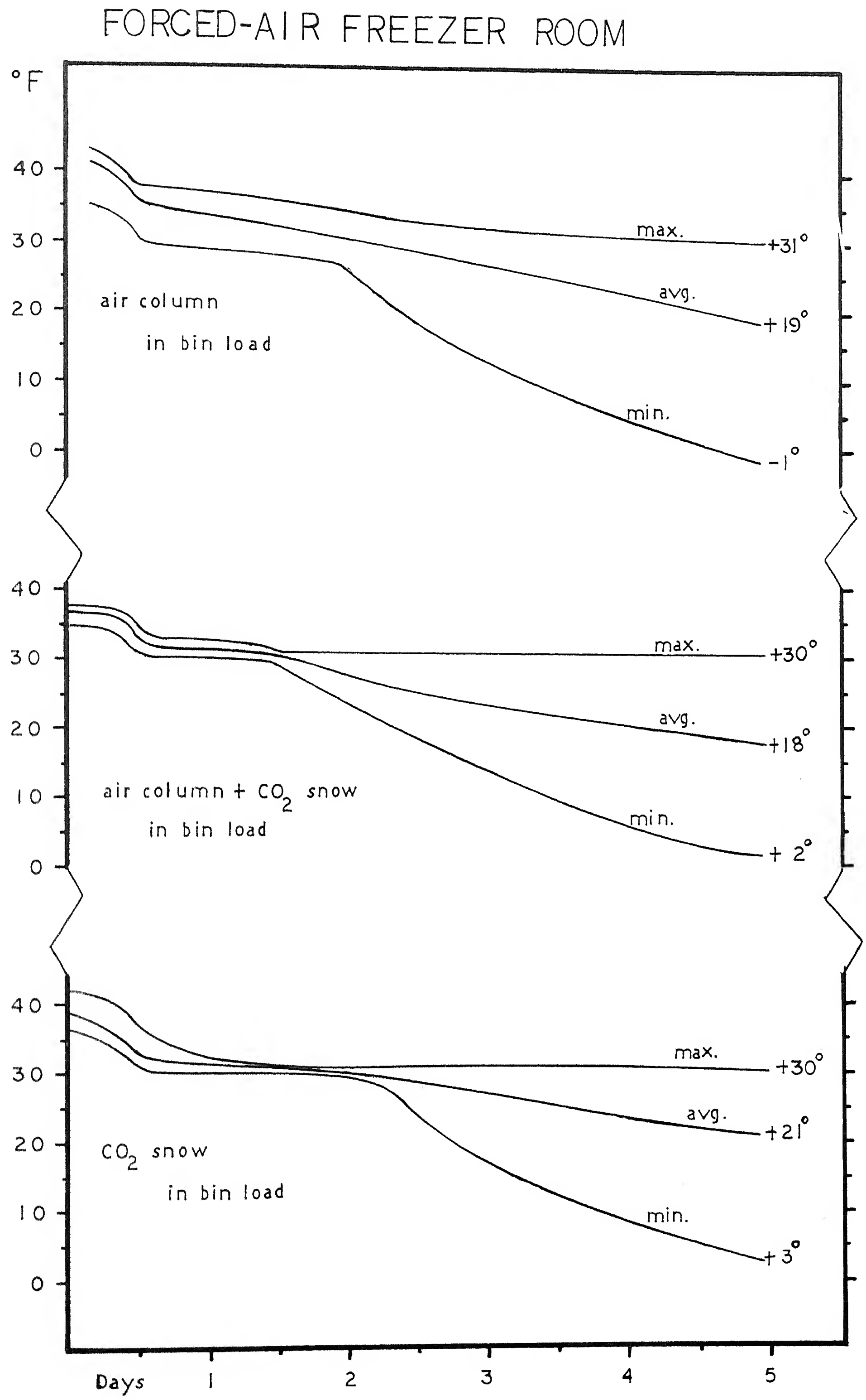

Figure 4.--Freezing curves for three pallet bins of hams in a forced-air freezer room at -2° to -12° F and air velocities around the bins ranging from 150 to 200 fpm. The average curve is the mean temperature of five hams, whereas the maximum and minimum curves represent the temperature of a single ham.

The freezing curves showing average temperature in the bins plotted against time all show a steady rate of descent after about 2½ days of freezing (figs. 3 and 4). Assuming linearity in these curves from this point, the regression of time on temperature was calculated. The regression lines in figure 5 predict that it would have taken 8 days for the hams in the bins in the blast freezer to reach an average center temperature of 0° F compared with 11 days in the forced-air freezer room.

The freezing curves depicting the maximum temperature (figs. 3 and 4) within the bins are critical, since they represent the deeper locations in the bins or areas where heat removal is slowest and spoilage is most likely to occur. Spoilage of chilled pork results from the psychrotropic bacteria inherent on the surface of meat. These bacteria may cause the development of discoloration and off-odors at temperatures below the freezing point of meat (28° F). Although, as a general rule, fresh pork sanitarily slaughtered and rapidly chilled to and held at 30° F or below will keep up to 1 week without spoilage. 4/

Center temperature of hams in the deep locations in the pallet bins in the forced-air freezer room did not get below 30° F even after 5 days of freezing. Therefore, freezing in a forced-air freezer room at temperatures above -12° F and air velocities below 500 fpm is not considered a suitable alternative for freezing full pallet bin-lots of hams.

Center temperature of hams in the deep locations in the pallet bins in the blast freezer were all below 30° F within 2½ days. Under well-controlled conditions bulk bins of hams could be frozen by this method without serious risk of spoilage.

Separation of Frozen Hams

Unloading the bulk bins did not present a problem when the meat was hard frozen. A blow from another ham or a mallet easily shattered the ice holding the hams together. On the other hand, if the hams were only partially frozen or thawed enough to allow the skin to flex, it was very difficult to separate the individual pieces.

[illegible]/ [illegible] W. C. Food Microbiology. McGraw-Hill, New York,

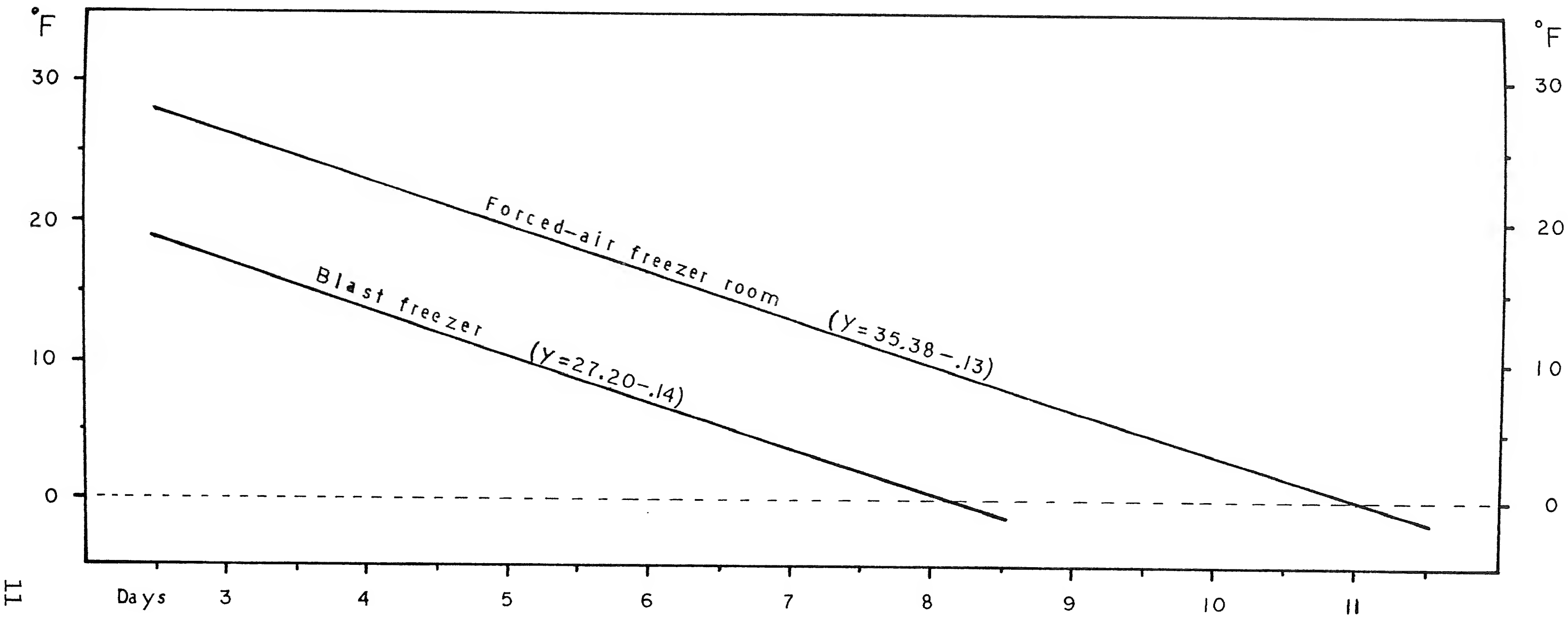

Figure 5.--Regression lines predicting the average freezing rate of hams in pallet bins in a blast freezer with temperatures ranging from -12° to -23° F and in a forced-air freezer room with temperatures ranging from -2° to -12° F.

CONCLUSIONS AND RECOMMENDATIONS

Fresh hams well chilled (36° to 40° F) and relatively fresh from the kill floor can be frozen in pallet bin lots up to 2,000 pounds in a blast freezer with unlikely losses from spoilage, where: (1) temperatures are maintained at -15° F or below, (2) air movement around the bin is at least 500 fpm, and (3) either an air column or CO_2 snow are used to assist heat removal in the blast freezer.

Distributing 100 or more pounds of CO_2 snow throughout each bin load of hams is recommended because of the bacteriostatic effect of the dissipating CO_2 gas and the ability of the snow to rapidly reduce the meat temperature.

Although fresh hams can be frozen physically in pallet bin lots, whether it is economically feasible is questionable considering the extra requirements for expeditious handling, extra energy requirements, and reduced utilization of the blast freezers. Freezing hand-stacked hams in a blast freezer to an average temperature of 0° F requires approximately 1 day, therefore, freezing hams in pallet bins would require eight times more energy and blast freezer time.

Other methods of freezing and handling hams in fiberboard bins may prove more feasible. A possible method is to partially freeze the individual hams to just past the point where the latent heat is removed (26° F) before they are packed in the fiberboard bins at the packinghouse and then finish freezing the pallet bin loads to storage temperature (0° F) in a blast freezer. More research will be required to determine the most efficient method for handling hams in this manner.

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